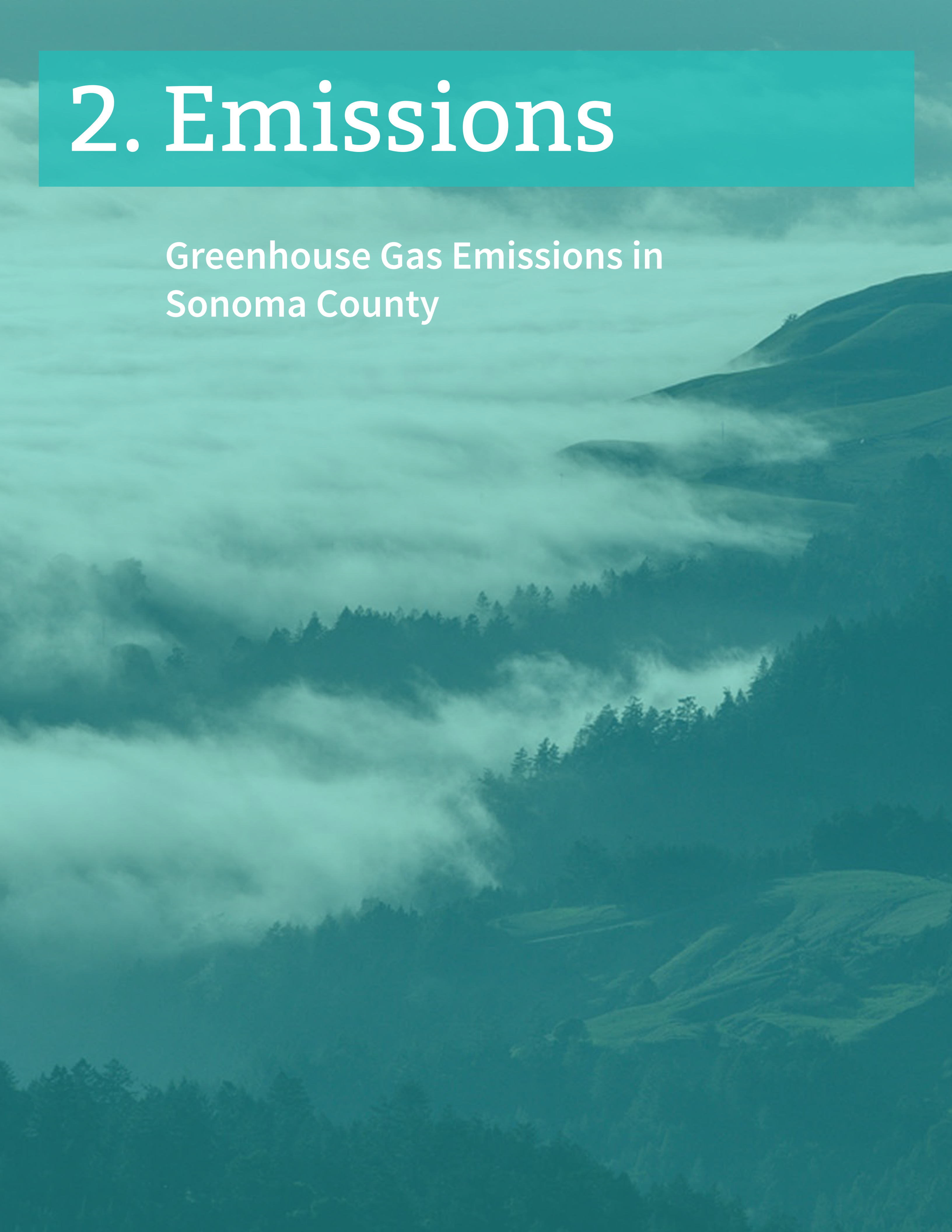
2. Emissions

Greenhouse Gas Emissions in Sonoma County



Chapter 2
Greenhouse Gas Emissions in Sonoma County

2.1 Introduction

Estimates of historic, current, and future greenhouse gas (GHG) emissions are essential to understanding local emissions sources that communities can influence to reduce local contributions to climate change. These estimates, referred to as *inventories*, help to define priorities for emissions reduction strategies and for tracking progress.

This inventory approach focuses on sources of emissions that a local jurisdiction can readily influence. It leaves out two important ways in which actions taken in Sonoma County influence GHG emissions: goods consumption (i.e., emissions that result from local consumption of goods produced in other places) and carbon sequestration (i.e., the removal of carbon from the atmosphere through actions to increase biological activity that stores carbon). Although not part of the inventory, these important aspects of understanding local opportunities to reduce GHG emissions are explored further in Section 2.5, below.

Several GHG inventories were developed for this plan. The 1990 *backcast* estimates historic emissions levels and serves as the baseline for measuring future GHG reductions; the 2010 inventory measures existing emissions sources and forecasts future emissions in 2020, 2040, and 2050 under a business-as-usual (BAU) scenario (i.e., without implementation of climate action strategies). More details on data sources and specific methods used for each sector can be found in Appendix B.

Roughly 4 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) emissions were generated by activities in Sonoma County in 1990 (see Table 2-1). By 2010, emissions were 7.7% lower, at about 3.7 $MMTCO_2e$. However, in the absence of state and local climate action, emissions are projected to grow to 4.4 $MMTCO_2e$ by 2020, largely driven by population and economic growth.

Table 2-1. Summary of Countywide Emissions

	Backcast	Inventory	Business-as-Usual Forecasts		
Key Climate Action Plan Indicators	**1990**	**2010**	**2020**	**2040**	**2050**
Countywide emissions ($MTCO_2e$)	3,966,000	3,659,000	4,395,000	4,964,000	5,147,000
Percent change from 1990	N/A	-8%	11%	25%	30%
Per capita emissions ($MTCO_2e$/person)	10.2	7.6	8.6	8.6	8.5
CA per capita emissions ($MTCO_2e$/person)[1]	14.5	12.1	12.5	12.9	13.8
Population (people)	388,222	483,878	509,766	578,329	604,851
Housing (housing units)	149,382	189,773	202,942	230,827	241,181
Employment (jobs)	172,064	202,123	229,710	247,980	256,846

[1] For details on how the California per capita emissions were estimated, please refer to Appendix C.

2.2 Measuring Emissions

2.2.1 What Is in the Inventories?

The inventories of community-wide GHG emissions in Sonoma County capture the primary sources of emissions that can be reduced through the actions of local governments and regional entities: energy use in our homes, businesses, vehicles, and off-road equipment; emissions from treating and delivering water; emissions from materials that are thrown away; and fertilizer and livestock operations. This approach is known as an “activity-based” inventory. It involves measuring or modeling the primary emissions-generating activities in Sonoma County and translating them into GHG emissions based on standard or locally specific emissions factors. Most sources included cause emissions within the county. However, some emissions that occur outside the county are also included but only to the extent that such emissions are the direct result of community activities that can be reduced through local actions. For example, GHG emissions from regional power plants that provide electricity to local homes and businesses are included, even though the power plants may not be located within the county.

Example: Estimating Building Energy Emissions

Here is a quick overview of how GHG emissions are estimated for the building energy sector:

Step 1: Determine which utilities supply electricity and natural gas to residents and businesses in the unincorporated areas.

Step 2: Obtain annual energy usage from the utilities. Electricity consumption is provided in terms of kilowatt hours, whereas natural gas usage is provided in terms of therms.

Step 3: Multiply electricity and natural gas quantities by GHG emission factors.

Step 4: Add emissions from electricity and natural gas to determine total GHG emissions from building energy use.

Local emissions-generating activities addressed in this plan are summarized in Table 2-2. The analysis of emissions includes carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Of these gases, CO_2 emissions contribute the most to global warming, both internationally and locally. In certain sectors (e.g., dairies and livestock, solid waste, wastewater treatment), CH_4 and N_2O play a more significant role. All three gases are expressed as metric tons of carbon dioxide equivalent ($MTCO_2e$), based on the global warming potential of these gasses relative to CO_2 (see Chapter 1).

Global Warming Potentials for Greenhouse Gases

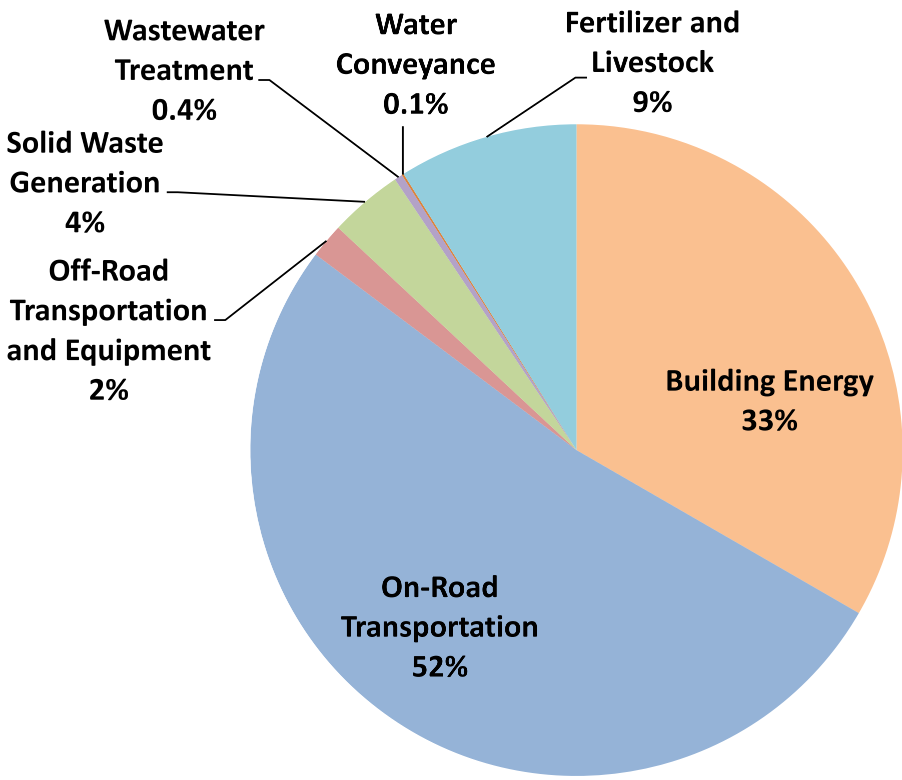
GHGs are not created equally. The Global Warming Potential, or GWP, is used to compare GHGs based on their potential to trap heat and remain in the atmosphere. Some gases can absorb more heat than others and thus have a greater impact on global warming. For example, CO_2 is considered to have a GWP of 1, whereas N_2O has a GWP of 265. This means that N_2O is 265 times more powerful than CO_2.

Table 2-2. Key Activity Data by Sector

Sector	Primary Emissions Sources	Key Activity Data	Data Sources
Building Energy	• Production of electricity (emissions generated at power plants) • Combustion of natural gas • Combustion of other fuels (e.g., propane, fuel oil, wood) in residences	• Total electricity use (megawatt hours) • Total natural gas use (therms) • Total fuel combustion for other fuels	• Electric utilities: Pacific Gas & Electric (PG&E), City of Healdsburg, Sonoma Clean Power (in years after 2010) • Natural gas utilities: PG&E • Other fuels
On-Road Transportation	• Combustion of gasoline and diesel fuel in vehicles • Combustion of fuels in transit vehicles	• Vehicle miles traveled • Fuel type and fuel economy of countywide vehicle fleet • Travel patterns	• Sonoma County Transportation Authority • California Air Resources Board's (ARB) EMFAC2011 model
Off-Road Transportation and Equipment	• Combustion of fossil fuels in equipment (e.g., cranes, bulldozers, lawn mowers) • Combustion of fossil fuels in off-road vehicles (e.g., ATVs, boats)	• Fuel consumption in off-road vehicles and equipment • Socioeconomic data	• ARB's OFFROAD 2007 and OFFROAD2011 model
Solid Waste Generation	• Methane emissions from decomposition of organic matter sent to landfills	• Tons of waste (residential and commercial) sent to landfills • Profile of waste material for residential and commercial waste in each jurisdiction (e.g., 19% paper, 36% food waste)	• Sonoma County Waste Management Agency
Wastewater Treatment	• Emissions of methane and nitrous oxide that occur during wastewater treatment	• Population served by each wastewater treatment plant (WWTP) • Method of wastewater treatment at each WWTP • Amount of digester gas produced at each WWTP	• Sonoma County Water Agency • Sanitation districts and jurisdictions that operate a WWTP
Water Conveyance	• Production of electricity associated with the pumping and movement of water from source to user (emissions generated at power plants)	• Water consumption • Water supply sources (e.g., groundwater, Russian River)	• Urban Water Management Plans for each jurisdiction • Sonoma County Water Agency
Livestock and Fertilizer	• Emissions of nitrous oxide from the application of fertilizer • Emissions of methane and nitrous oxide from livestock and manure management	• Acres and types of crops grown in the county • Livestock population numbers	• Sonoma County Agricultural Commissioner

The 2010 countywide inventory reveals that two activities are responsible for 85% of locally generated emissions: transportation and building energy use (see Figure 2-1). Livestock and fertilizer, solid waste, water, and off-road equipment represent smaller sources in Sonoma County; however, these activities still hold opportunity for emissions reductions.

Figure 2-1. 2010 Countywide GHG Emissions by Sector



2.2.2 Which Years Were Measured?

Several GHG profiles were developed for Climate Action 2020 (CA2020):

1990 Backcast: An estimate of community-wide emissions levels in 1990 was developed to understand historic emissions levels in Sonoma County and provide a baseline for measuring future GHG reductions. This baseline year aligns with the statewide baseline in Assembly Bill 32, California's climate action framework through 2020. Emissions data for 1990 are not available for all sectors to the degree they are available now; therefore, 1990 levels were estimated with available socioeconomic and sector-specific data and emissions factors when possible, using the same protocol for the 2010 inventory and future forecasts.

2010 Inventory: The 2010 community inventory was developed by using actual activity data, such as kilowatt-hours and vehicle miles traveled, as reported by utilities and other local agencies. Emissions generated by community activities were analyzed using widely accepted methodologies and procedures recommended by federal, state, and local air quality management agencies. The primary protocol used was the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* (ICLEI – Local Governments for Sustainability 2012). In that protocol, 2010 was chosen with the input of the jurisdictions and other relevant stakeholders, taking into account data availability and completeness. A key consideration was the existence of highly reliable socioeconomic information from the 2010 U.S. Census.

Business-as-Usual (BAU) Forecast: GHG emissions forecasts for 2015, 2020, 2040, and 2050 were based on projected growth in population, employment, and households in the county (see Table 2-1). Forecasts for 2015 and 2020 were developed to evaluate the magnitude of the challenge in meeting the short-term target of 25% below 1990 levels. Forecasts even further into the future (2040 and 2050) were developed to help prepare the county to meet long-term GHG reduction goals. Data used for the BAU forecasts are predictions of community emissions that would occur in future years without accounting for federal, state, and local actions to reduce GHG emissions. Although Sonoma County's GHG reduction target is based on a 1990 baseline, the BAU forecasts also help show the magnitude of the challenge to reach the target.

Analysis was done for each sector within the inventory and for each jurisdiction in Sonoma County. Detailed methodologies for calculating emissions for each sector, jurisdiction, and year are provided in Appendix B.

2.3 Inventory Results

2.3.1 GHG Emissions in Sonoma County by Sector

This section begins with an overview of GHG emissions in all sectors, calculated as outlined in Appendix B, followed by a more detailed description of existing emissions in each sector (see Table 2-3 and Figure 2-2). These sector-specific discussions provide a deeper exploration of the main factors that influence GHG emissions. This analysis was then used to identify the most effective emissions reduction opportunities, which are reflected in the reduction measures in Chapter 4.

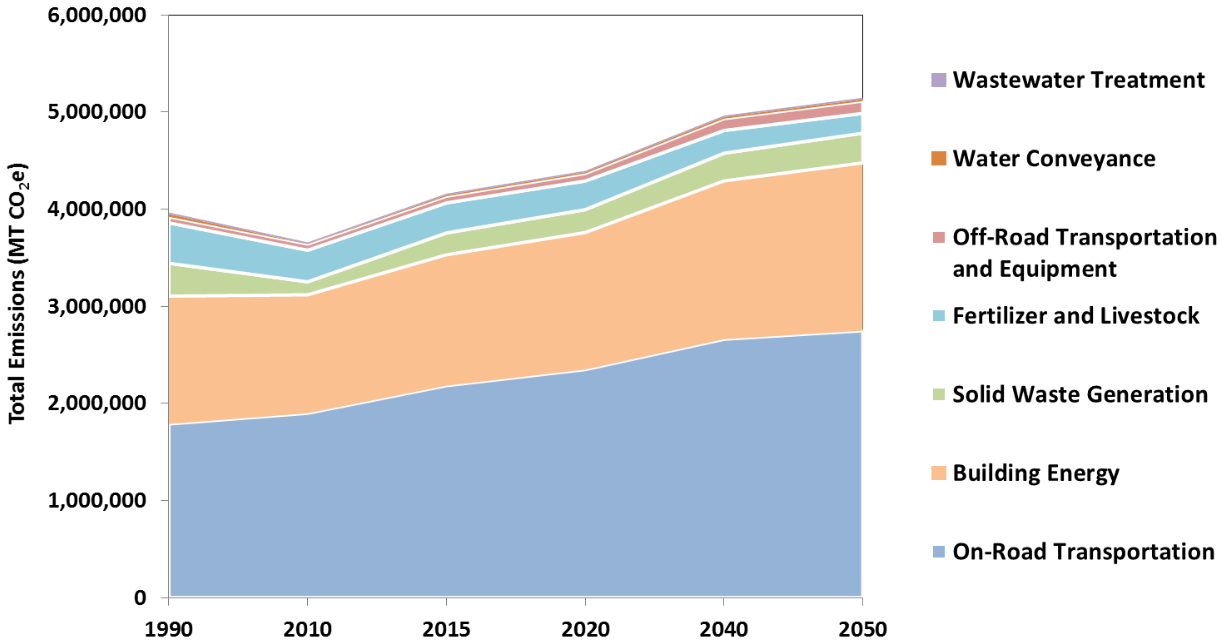
Table 2-3. GHG Inventory and Forecast Results by Sector, and Year

Emission Sector	Emissions ($MTCO_2e$)					
	Backcast	Inventory	BAU Forecasts			
	1990	2010	2015	2020	2040	2050
Building Energy	859,100	1,219,800	1,347,400	1,410,500	1,629,900	1,728,100
On-Road Transportation	1,203,400	1,899,300	2,183,400	2,349,500	2,661,500	2,749,400
Off-Road Equipment	42,900	62,500	68,500	77,300	121,600	126,600
Solid Waste Generation	281,200	133,600	224,900	235,900	285,100	305,700
Wastewater Treatment	14,900	14,500	13,400	13,600	14,800	15,500
Water Conveyance	26,600	3,500	13,000	13,600	17,000	18,400
Fertilizer and Livestock	415,100	325,700	309,600	294,800	234,100	203,700
Santa Rosa 1990 Emissions[1]	1,123,100	—	—	—	—	—
Sonoma County Total	3,966,000	3,659,000	4,160,000	4,395,000	4,964,000	5,147,000

Notes:

[1] Santa Rosa's emissions in 1990 are not available from the city's Climate Action Plan (CAP); 1990 emissions were thus assumed to be equal to 15% below the baseline level of emissions, per the city's CAP. As a result, sector emissions for Santa Rosa in 1990 are not available and are included as a separate line item. Santa Rosa emissions for all other years are disaggregated into each sector.

Figure 2-2. Countywide GHG Inventory and Forecast Results by Sector and Year[1]



Transportation and building energy generate the vast majority of local GHG emissions and, without effective reduction measures, emissions in these sectors will steadily increase as the county's population and employment increase. Fortunately, these two sources also present the greatest opportunities for GHG emission reductions. Emissions in the solid waste and water conveyance sectors decreased dramatically between 1990 and 2010 because of increased waste diversion efforts and more efficient water delivery methods. Emissions in the wastewater treatment sector were approximately the same in 1990 and 2010 despite an increase in population, most likely due to a shift to less emissions-intensive wastewater treatment methods and a decline in per capita wastewater flows. Fertilizer and livestock emissions declined between 1990 and 2010 and will continue to do so in future years because of declining livestock-related agriculture in the county.

Countywide GHG emissions decreased by 7.7% between 1990 and 2010 but will increase by 11% between 2010 and 2020 under BAU conditions, absent any GHG reduction effort. Most of the projected increase in BAU emissions between 2010 and 2020 is due to increases in emissions from building energy use and on-road transportation resulting from growth in population and housing. These sectors will also increase as a result of new development by 2020.

By 2050, BAU emissions are forecast to grow by 41% from 2010 levels to more than 5 million metric tons. Again, most of that growth will be driven by building energy use and transportation.

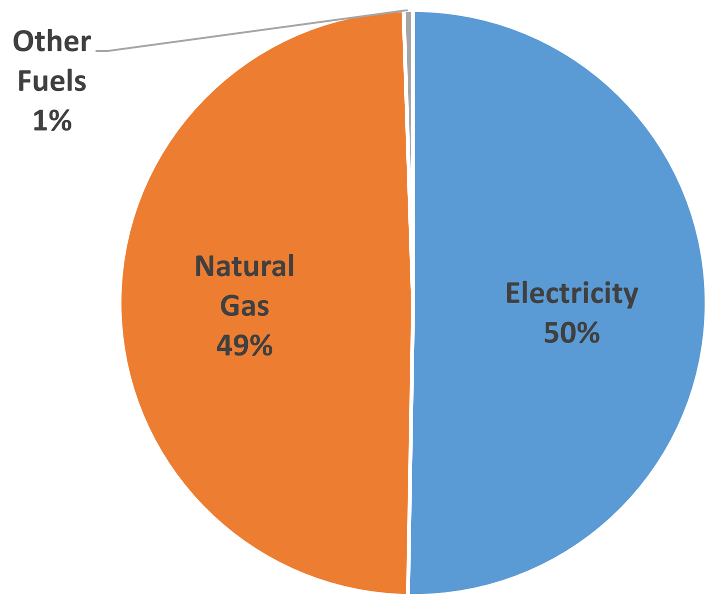
[1] The 1990 emissions in this chart include Santa Rosa's total 1990 emissions apportioned to each sector using the 2010 inventory sector distribution for the city (actual 1990 emissions by sector are not available).

Existing Emissions from Building Energy

Electricity production and the direct combustion of natural gas in buildings generated more than **1.2 million $MTCO_2e$ in 2010**, making building energy use the second-largest source of community emissions (about 33%), behind on-road transportation. Increases in population and employment, along with rising temperatures and cooling demands, will increase building energy use and associated GHG emissions in the future without further action.

Building Energy Emissions by Fuel. Roughly 50% of total building energy emissions come from electricity generation, and 49% comes from the combustion of natural gas (see Figure 2-3). A relatively small amount of other fuels—wood, propane, and kerosene—are used in buildings in Sonoma County, representing 1% of building energy emissions.[2] Building energy measures in CA2020 are focused on the two major fuels used in buildings, although measures that improve building energy efficiency will also reduce emissions related to other fuels.

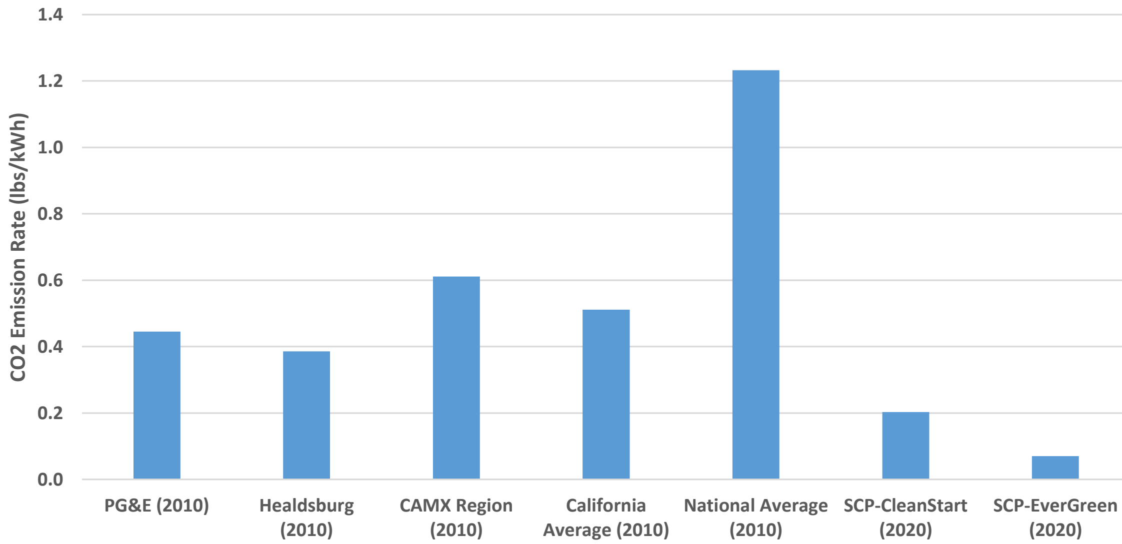
Figure 2-3. Building Emissions by Fuel



As shown in Figure 2-4, the electricity consumed in Sonoma County in 2010 was already relatively low in GHG intensity, compared to both U.S. and California averages. The two primary utilities serving the county in 2010—Pacific Gas & Electric Company (PG&E) and Healdsburg Electric—achieved lower emissions by procuring electricity generated by low-carbon and renewable sources, including hydropower, wind, solar, and geothermal.

[2] Approximately 6% of homes in the County use these fuels. GHG emissions represent only 1% of total building energy emissions because the sector also includes electricity emissions and nonresidential emissions.

Figure 2-4. CO_2 Emissions Factor Comparison by Utility/Region



Continued pursuit of zero-carbon electricity sources presents a major opportunity to reduce emissions in Sonoma County. This includes both on-site electricity generation (such as rooftop solar) and reduced- or zero-carbon electricity generation portfolios provided by utilities. Sonoma Clean Power (SCP) was created in 2014 to offer low-carbon and zero-carbon electricity options for homes and businesses in Sonoma County. The predicted GHG intensity of SCP electricity in 2020 is also shown in Figure 2-4. Over time, both PG&E and SCP will pursue increasingly more renewable generation to comply with state climate and energy goals and ultimately surpass those state goals.

The 2014 power mixes for PG&E and SCP are shown in Figure 2-5.

Another opportunity to reduce emissions is presented by reducing or replacing natural gas with on-site photovoltaic (PV) electric generation. SCP, the County of Sonoma Energy and Sustainability Division, and the Northern Sonoma County Air Pollution Control District will be involved in creating the incentives to support this measure.

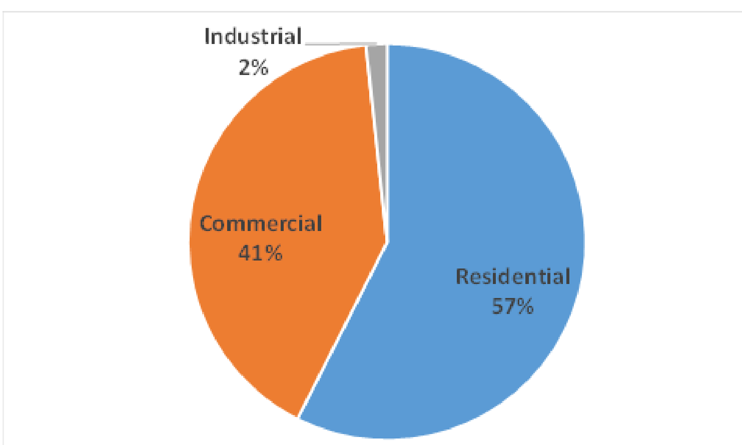
Figure 2-5. Comparison of PG&E and SCP 2014 Electric Power Generation Mixes

Electric Power Generation Mix*	PG&E	Sonoma Clean Power CleanStart	Sonoma Clean Power EverGreen
Specific Purchases	**Percent of Total Retail Sales (kWh)**		
Renewable	27%	36%	100%
• Biomass & Biowaste	5%	3%	0%
• Geothermal	5%	12%	100%
• Eligible hydroelectric	1%	0%	0%
• Solar electric	9%	0%	0%
• Wind	7%	21%	0%
Coal	0%	0%	0%
Large hydroelectric	8%	44%	0%
Natural Gas	24%	0%	0%
Nuclear	21%	0%	0%
Other	0%	0%	0%
Unspecified Sources of Power	21%	20%	0%
TOTAL	**100%**	**100%**	**100%**

*The generation data represents 2014 and is provided in the "Annual Report to the California Energy Commission: Power Source Disclosure Program," excluding voluntary unbundled renewable energy credits. PG&E data is subject to an independent audit and verification that will not be completed until October 1, 2015.

Building Energy Emissions by End Use. Different building types use energy for different purposes, with different opportunities to reduce emissions (see Figure 2-6). In 2010, roughly 58% of building energy was used in homes, compared with 42% used in businesses, institutions, and other nonresidential settings.

Figure 2-6. Building Energy Emissions by Sector



Residential buildings consume energy for heating, cooling, hot water, lighting, and appliances. Policies and programs to reduce emissions from residential buildings must focus on reducing energy demand through conservation and improvements to building energy efficiency and meeting demand with low- or zero-carbon energy sources.

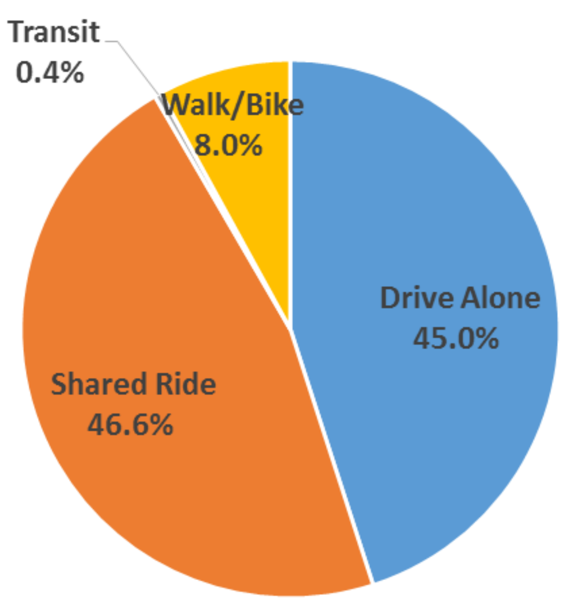
The energy needs of commercial buildings are more diverse. A retail building may have energy needs for lighting and air conditioning, while a hotel may have a very large demand for hot water. Measures to address emissions from nonresidential buildings must be designed with the unique needs of commercial and industrial buildings in mind.

Existing Emissions from Transportation

On-road transportation is the largest sector of GHG emissions for the county; approximately 52% of total countywide emissions are from transportation, or nearly **2 million $MTCO_2e$.** Vehicle trips made by residents and employees within the county are expected to increase as the population and economy grow. Strategies to support alternative modes of transportation, improve transportation efficiency, and reduce vehicle miles traveled are therefore an essential part of CA2020.

Transportation Emissions by Mode. In 2010, motorists traveled more than 11 million vehicle miles in Sonoma County each day. These trips were taken primarily in passenger vehicles, with additional trips by commercial vehicles, transit vehicles, and other vehicle types. Figure 2-7 shows a breakdown of daily countywide trips by mode for 2010 for all trip purposes (e.g., home to work, home to school, nonresidential), as provided by the Sonoma County Transportation Authority.

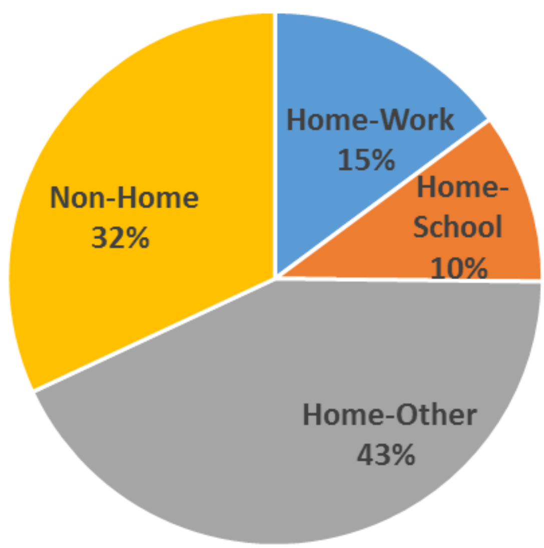
Figure 2-7. Sonoma County Daily Trips by Mode for 2010



Transportation Emissions by Purpose. Opportunities to reduce emissions from transportation must be based on an understanding of how, why, and where people travel in Sonoma County. The Sonoma County Transportation Authority's Comprehensive Transportation Plan provides a 25-year transportation vision for Sonoma County. Comprehensive Transportation Plan goals include maintaining the current transportation system, reducing traffic congestion, reducing GHG emissions, improving safety and health, and promoting economic vitality. The plan includes bicycle and pedestrian projects, highway and local road infrastructure projects, technology projects (e.g., energy-efficient streetlights and signal timing), smart land use projects, and transit projects.

Most trips in Sonoma County (about 68%) are home-based trips. About two-thirds of these home-based trips are for purposes other than getting to/from work or school. Non-home trips include all trips that do not begin or end at home, including commercial or business-related trips. Figure 2-8 shows a breakdown of daily countywide trips by purpose for 2010, as provided by the Sonoma County Transportation Authority.

Figure 2-8. Sonoma County Daily Trips by Purpose for 2010

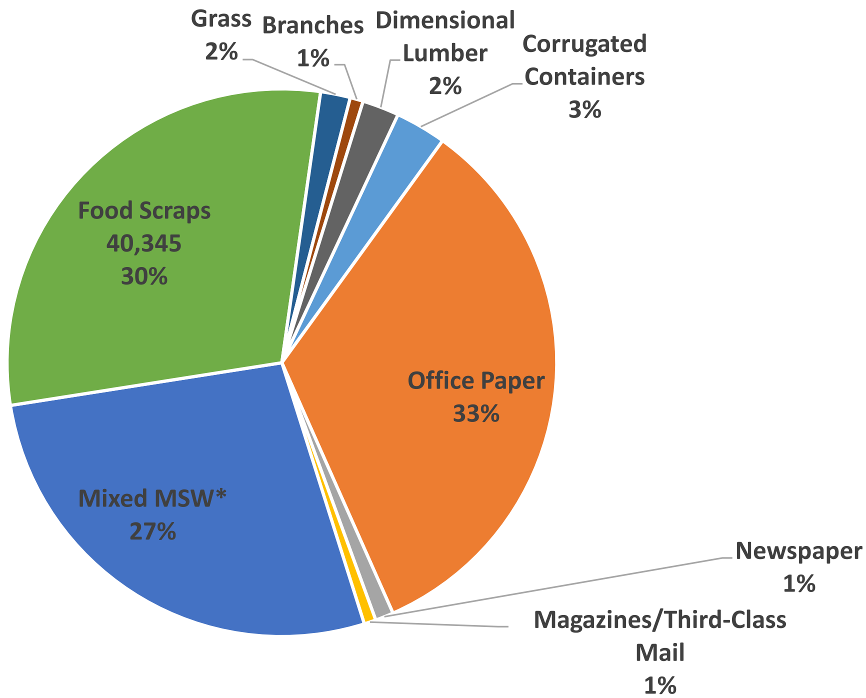


Existing Emissions from Solid Waste

In 2010, county residents and businesses generated an estimated 1.3 million tons of solid waste, 350,000 tons of which was landfilled, generating about **134,000 $MTCO_2e$** (about 4% of total 2010 emissions). About 58% of this waste comes from commercial sources and 42% from residential sources. Increasing population and employment means more solid waste and associated GHG emissions in the future without further action. Strategies to reduce waste generation, increase waste diversion from landfills (such as through recycling and composting), and increase methane capture are therefore essential parts of CA2020.

Waste landfilled in the county includes a variety of waste categories, such as paper, plastic, glass, and food. Figure 2-14 shows a breakdown of waste emissions by waste type for 2010.

Figure 2-14. Sonoma County Solid Waste Emissions by Waste Type for 2010



* "Municipal solid waste" or "MSW" means all solid wastes generated by residential, commercial, and industrial sources, and all solid waste generated at construction and demolition sites, at food-processing facilities, and at treatment works for water and waste water, which are collected and transported under the authorization of a jurisdiction or are self-hauled. Municipal solid waste does not include agricultural crop residues, animal manures, mining waste and fuel extraction waste, forestry wastes, and ash from industrial boilers, furnaces and incinerators (see: http://www.calrecycle.ca.gov/laws/regulations/title14/ch9a3.htm).

Existing Emissions from Water Conveyance and Wastewater Treatment

In 2010, energy used to convey potable water and treat wastewater resulted in GHG emissions of more than **18,000 $MTCO_2e$** (about 0.5% of total 2010 emissions). County residents and businesses consumed more than 20 billion gallons of water in 2010 and are expected to consume nearly 27 billion gallons by 2020 under BAU conditions, an increase of 28%. This increased water use also means more wastewater generation, resulting in increased GHG emissions in the future without further action. Water resources, including surface and groundwater, are essential parts of the county community and economy. Given the potential for future reductions in water supplies as a result of climate change, water conservation and wastewater treatment are critical strategy areas for CA2020.

The water conveyance emissions addressed in this sector include those from large municipal water providers including, but not limited to, the Sonoma County Water Agency (SCWA) wholesale water system, systems operated by SCWA's retail water contractors, and the smaller supplier-produced groundwater providers. Electricity use (and associated emissions) for private domestic and agricultural wells is accounted for in CA2020 under the building energy sector.

Water Use by Source and End Use. Water conveyance resulted in approximately 3,600 $MTCO_2e$ of emissions in the county in 2010. These emissions represent energy use for water supply and treatment activities and include SCWA operations, groundwater pumping, and recycled water use. SCWA is a water wholesaler that provides water to retail water contractors (primarily cities and water districts). The 2010 emissions from water conveyance are already lower than they would be otherwise because of SCWA's program to create a zero-carbon water system by 2015. SCWA water contractors provide about 56% of the water supply within the county. End uses of this water include residential, commercial, landscaping, and other uses. Single- and multi-family residential water use represents 68% of all water deliveries by retailers in the county.

Figure 2-15 shows a breakdown of water supply by source for 2010, while Figure 2-16 shows a breakdown of water use by sector for 2010

Figure 2-15. Sonoma County Water Supply by Source for 2010

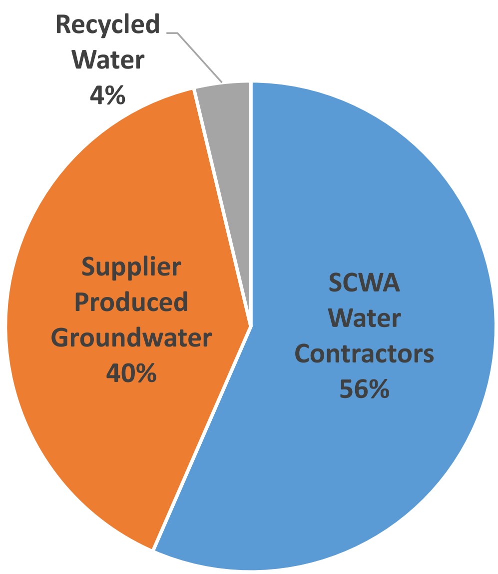
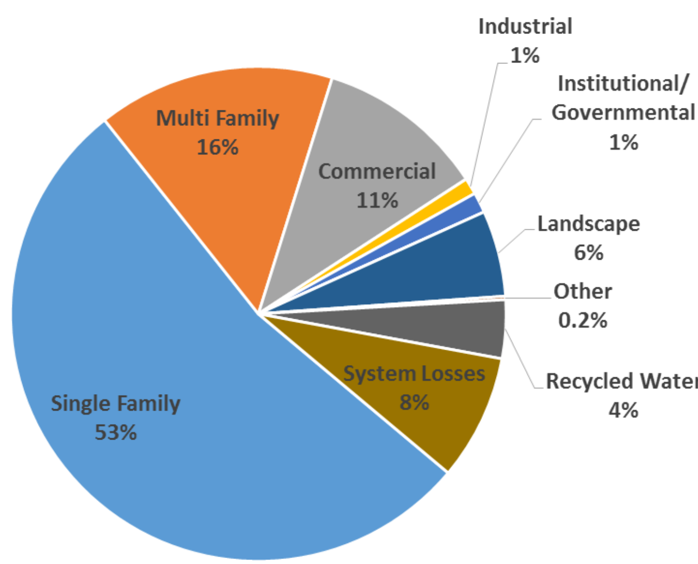
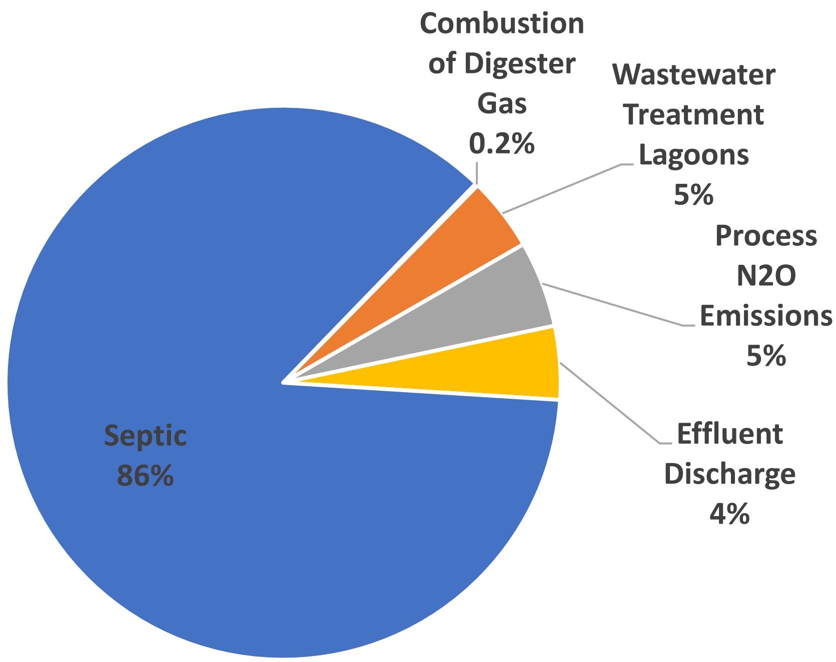


Figure 2-16. Sonoma County Water Use by Sector for 2010



Wastewater Emissions by Source. Wastewater treatment resulted in approximately 15,000 $MTCO_2e$ of emissions in the county. Wastewater treatment includes a variety of different processes, each of which releases CH_4 and N_2O emissions. The majority (86%) of wastewater emissions in the county are from individual septic systems, which serve approximately 24% of the countywide population. Wastewater treatment plants (WWTPs) serve the remaining 76% of the county population, and emissions from WWTPs represent 13% of total wastewater treatment emissions (WWTPs produce fewer emissions per person served than septic systems). Figure 2-17 shows a breakdown of wastewater emissions by source for 2010.

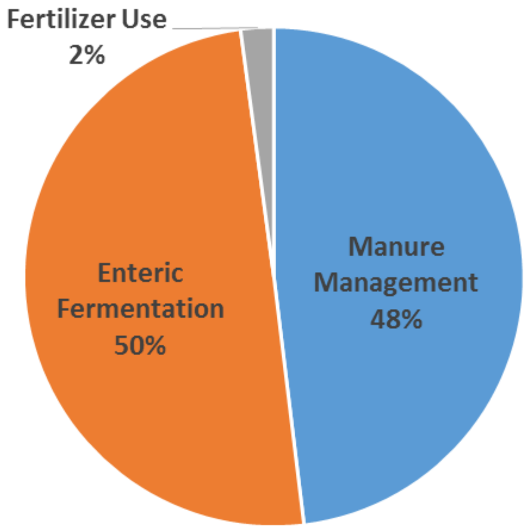
Figure 2-17. Sonoma County Wastewater Emissions by Source for 2010



Existing Emissions from Livestock and Fertilizer

Livestock and fertilizer emissions are the third-largest source of emissions in Sonoma County overall after transportation and building energy, accounting for just under **9% of emissions in 2010** (see Figure 2-9). The primary emissions included in this sector are CH_4 generated by manure storage and enteric (digestive) fermentation and N_2O generated by fertilizer application.

Figure 2-9. Livestock and Fertilizer Emissions by Source

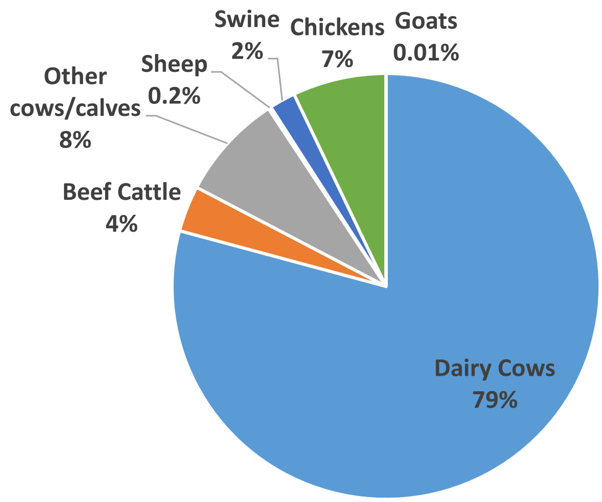


Methane and Nitrous Oxide from Livestock Operations. The majority (98%) of emissions from livestock and fertilizer come from livestock operations (mostly dairy cows) (see Figure 2-10). These emissions arise from the management of livestock manure and livestock enteric fermentation (digestion).

Manure creates both CH_4 and N_2O as it biodegrades. The amount of CH_4 generated is related to the type of manure management used. Manure management systems include pasture/range/paddock, drylot, solid storage, liquid/slurry, daily spread, anaerobic lagoon, deep pit, and anaerobic digester.

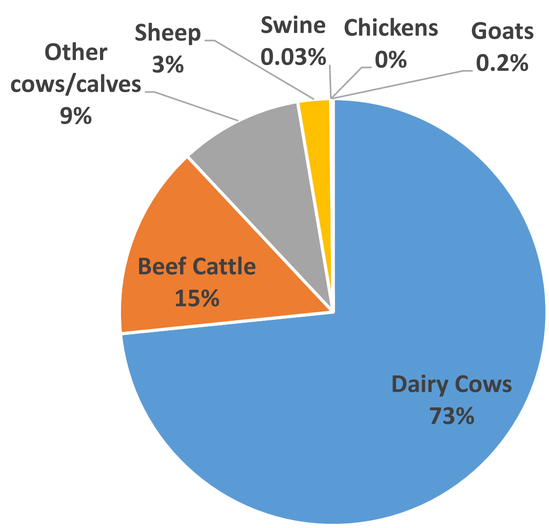
Significant opportunity exists to promote manure management practices that reduce emissions, including practices that rely on anaerobic digesters, composting, and waste-to-energy facilities.

Figure 2-10. Manure Management Emissions by Livestock Type



The other major emissions source is enteric fermentation, again mostly from dairy cows (see Figure 2-11). Enteric fermentation is the process of microbial fermentation that produces CH_4 during animal digestion (ICLEI – Local Governments for Sustainability 2012).

Figure 2-11. Enteric Fermentation Emissions by Livestock Type

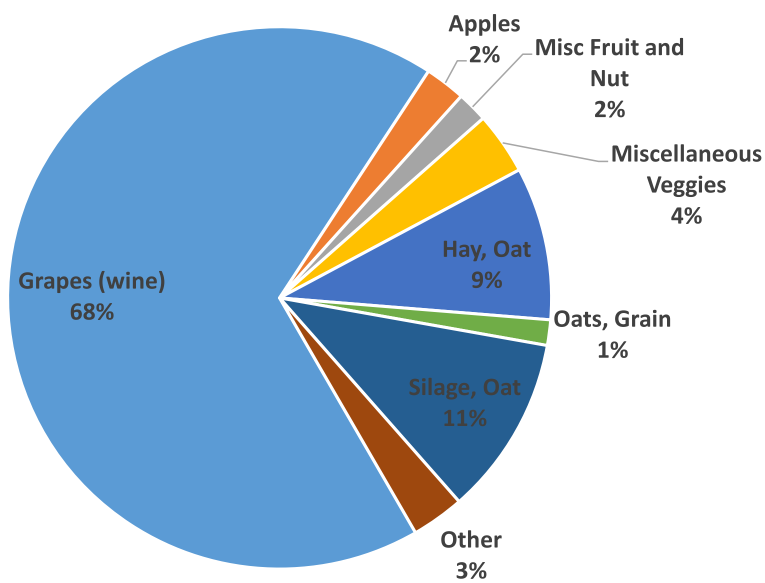


CH_4 emissions can be reduced through animal diets that create a digestive environment that is less conducive to methanogens, although opportunities to significantly reduce enteric emissions are currently limited. Such options include dietary oils (e.g., whole cottonseed oil, sunflower oil, coconut oil, palm oil), the use of corn or legume silage in place of grass silage, and the use of concentrate feeds, nitrates, ionophores, and tannins. Improving forage quality and overall efficiency in dietary nutrient use are other options.

Emissions from Fertilizer Use. The remainder (2%) of emissions in the livestock and fertilizer sector is mainly from the application of nitrogen-based fertilizers (see Figure 2-12). N_2O is emitted when nitrogen is added to the soil through the use of synthetic fertilizers. Fertilizer application is the largest source of N_2O emissions in the U.S., accounting for about 74% of total U.S. N_2O emissions in 2013 (U.S. Environmental Protection Agency 2015). Different crops use fertilizer at different rates; therefore, the rate of emissions from fertilizers varies by crop type; soil management, including irrigation; and fertilizers used.

Despite having a relatively low rate of fertilizer use, wine grape production in the county is responsible for the majority of N_2O emissions associated with fertilizer use because of the total amount of acreage devoted to wine grapes (see Figure 2-13).

Figure 2-13. Total Fertilizer Emissions by Crop Type



Source: U.S. Department of Agriculture National, Agricultural Statistics Service. 2013. *QuickStats Ad-hoc Query Tool.* Available: http://nassgeodata.gmu.edu/CropScape/. Accessed: November 2013.

2.3.2 GHG Emissions in Sonoma County by Jurisdiction

Changes in emissions by jurisdiction over time are a product of a number of factors, including economic and population growth, annexations, urban growth boundaries, an emphasis on city-centered growth, and changes in efficiency, energy sources, and behavior (see Table 2-4).

Forecasts for future growth in emissions by jurisdiction are based on socioeconomic projections developed by each jurisdiction. More discussion of the factors that drive growth (or reductions) in emissions within in each jurisdiction's boundary over time is provided in Chapter 5, *Community Greenhouse Gas Profiles and Emissions Reductions for 2020*.

Table 2-4. GHG Inventory and Forecast Results by Jurisdiction and Year

Jurisdiction	Emissions ($MTCO_2e$)					
	Backcast	Inventory	BAU Forecasts			
	1990	2010	2015	2020	2040	2050
Emissions by Jurisdiction						
Cloverdale	57,300	59,000	69,300	73,300	93,200	93,800
Cotati	51,500	52,100	57,300	61,300	69,000	70,900
Healdsburg	93,500	108,800	117,000	121,000	123,700	121,100
Petaluma	387,000	441,900	505,000	543,000	580,900	588,600
Rohnert Park	291,300	264,300	317,400	372,700	371,800	378,600
Santa Rosa*	1,123,100	1,065,200	1,338,400	1,396,900	1,844,700	2,027,500
Sebastopol	73,200	76,300	85,300	93,000	96,500	97,100
Sonoma	96,900	103,400	117,400	122,200	132,500	131,200
Windsor	133,000	157,800	178,300	188,100	212,000	216,500
Unincorporated Sonoma County	1,244,300	1,004,500	1,065,300	1,128,800	1,205,600	1,218,300
Emissions Not Assigned to Individual Communities						
Fertilizer and Livestock	415,100	325,700	309,600	294,800	234,100	203,700
Sonoma County Total	**3,966,000**	**3,659,000**	**4,160,000**	**4,395,000**	**4,964,000**	**5,147,000**

* 2040 and 2050 forecasts for Santa Rosa were derived from the City's CAP. Emissions for each sector for the years 2020 and 2035 were linearly extrapolated to 2040 and 2050.

2.3.3 How Does This Analysis Differ from Previous Inventories?

The GHG inventories prepared for Climate Action 2020 are the most comprehensive look at community-wide GHG emissions in the county to date. This is the first time that a community-wide measurement for each jurisdiction has been completed across all seven sectors. They are also based on the most current emissions factors and methodologies in use for community climate action planning in California. However, this is not the first time emissions have been measured in Sonoma County. Local governments and community-based organizations have been measuring

Municipal GHG Inventories in Sonoma County:

In 2002 and 2003, the Sonoma County jurisdictions prepared municipal GHG inventories, with assistance from the Climate Protection Campaign. The Climate Protection Campaign helped the jurisdictions track and reduce emissions from their municipal operations, using a variety of tools, and released annual GHG report cards.

GHG emissions since the early 2000s. Because of differences in protocols, datasets, and emissions factors used, past measurements cannot be compared directly against CA2020 measurements. Nonetheless, they are still important benchmarks in the history of climate action in Sonoma County. The community-wide inventories developed by the Center for Climate Protection (formerly the Climate Protection Campaign) reveal a trend over time that helps show how local climate leadership has influenced local emissions. The inventories prepared by the Center for Climate Protection can be found on its website (http://climateprotection.org/our-work/reports/).

The City of Santa Rosa adopted a community climate action plan in 2012. The inventory developed by Santa Rosa for its CAP was calculated by using the best available data and methodology at the time. Santa Rosa's 2007 baseline inventory provides a foundation for the City's adopted target to reduce emissions to 25% below 1990 levels by 2020 (the City's 1990 emissions estimate was calculated as 15% below the 2007 baseline inventory). Santa Rosa's inventory and estimated GHG reductions through measures in its CAP have been integrated into CA2020 through inclusion of the city's commitments in Chapter 3, *Reducing Community Emissions*, and Chapter 5, *Community Greenhouse Gas Profiles and Emissions Reductions for 2020*. An updated 2010 inventory for the City of Santa Rosa is included to give the city more information about progress toward its 2020 target and provide a consistent data set for all jurisdictions. Updated 2020, 2040, and 2050 BAU forecasts for Santa Rosa were not conducted; the forecast values in this document are derived from Santa Rosa's CAP. Emissions for each sector for the years 2020 and 2035 were linearly extrapolated to 2040 and 2050.

2.4 Other Emissions Sources and Carbon Sinks

The activity-based GHG inventory approach outlined in Section 2.2 does not include all human activities in Sonoma County that drive an increase or decrease in atmospheric GHG emissions. CA2020 does not address every source of emissions; rather, it tries to move the needle on the largest emissions sources that can most directly be influenced by local government action.

Several categories of emissions were excluded from the community-wide GHG inventory.

- Industrial and commercial stationary sources
- Carbon sinks through biologic carbon sequestration
- Consumption of goods and services imported into Sonoma County
- Air travel

These additional sources and sinks are explored in the following sections.

2.4.1 Industrial and Commercial Stationary Sources

Emissions from existing industrial and commercial stationary sources (except for natural gas combustion) are not included in the GHG inventory because the County and cities have limited jurisdictional control over existing large stationary sources. Large, stationary point-source emissions are regulated by the State of California (under Assembly Bill 32 through cap and trade) and through the U.S. Environmental Protection Agency (under the Clean Air Act) for GHG emissions. New stationary source emissions that are also subject to local land use authority could be subject to additional emissions reductions mandated by a local entity. However, any such requirements would need to account for state and federal regulation of such sources before determining if additional reductions are needed. Such determinations are highly source specific, given the complexity of state and federal regulations. As such, the forecasts in CA2020 exclude new industrial and commercial stationary sources. These sources are not covered by CA2020 but would need to be addressed on a case-by-case basis if and when a local land use authority has jurisdiction over such new sources. These sources include combustion of fossil fuels of any type, *except* natural gas (such as diesel, fuel oil, propane, kerosene, wood, digester gas, etc.), and fugitive emissions from industrial processes for each jurisdiction.

Natural gas use in the industrial and commercial sectors is included as part of the inventory and forecasts for CA2020. Stationary fuel combustion and process emissions in the industrial and commercial sectors associated with fuels other than natural gas were not included because of data limitations as well as concern about duplication of state and federal regulation of such point sources.

2.4.2 Carbon Sequestration

Carbon sequestration is the process of increasing the carbon content of a reservoir other than the atmosphere, thereby reducing atmospheric carbon. Although CA2020 focuses on reducing sources of GHG emissions caused by human activities, Sonoma County is also taking steps to understand how human activities influence the biologic carbon cycle and support land management practices that afford significant opportunities to sequester carbon emissions.

Natural and working lands are essential assets because of the many ecosystem services they provide as well as their essential role in a healthy county economy. Many adaptation objectives are furthered through the preservation and enhancement of green infrastructure, including trees, vegetation, and soils, as outlined in Chapter 2, *Greenhouse Gas Emissions in Sonoma County*.

Green infrastructure is a "cost effective, resilient approach to managing wet weather impacts that provides many community benefits."

Ecosystem services are "the many life sustaining benefits we receive from nature—clean air and water, fertile soil for crop production, pollination, and flood control."

U.S. Environmental Protection Agency

Green infrastructure can also help reduce carbon in the atmosphere by sequestering and storing carbon. Various ecological processes transfer carbon between the atmosphere, vegetation, and the soil, including photosynthesis, respiration, and decomposition. This terrestrial, or biologic, sequestration generates three primary pools of carbon stock in Sonoma County: agricultural lands, non-agricultural rural lands, and urban forests.

Sonoma County Vegetation Mapping Project

The Sonoma County Vegetation Mapping Project is a program of the Sonoma County Agricultural Preservation and Open Space District and SCWA, with contributions from the National Aeronautics and Space Administration, The Nature Conservancy, and the University of Maryland. The mapping project is part of a larger effort known a Climate Action Through Conservation (CATC), which provides a way for local governments, land managers, and planners to understand the links between climate benefits and conservation values and incorporate that knowledge into decisions about land use and land management.

Data from this mapping project include the types of vegetation and physical features in the County and are the products are publicly available. The project also includes an estimation of the carbon stocks in the County's natural and working lands and these data were used in part as the basis of the existing carbon stock estimates presented in this CAP.

The estimates of existing carbon stocks in Table 2-5 show the value of preserving natural and working lands and the biological processes on them. Conversely, this analysis can help to evaluate the impact of development and land cover change that results in a loss of carbon sequestration and a net increase in atmospheric carbon.

Table 2-5. 2010 Estimates of Countywide Carbon Stocks

Carbon Stock	Description	Total Stock in 2010 (Metric Tons Carbon)	Data Sources
Agricultural carbon stock	Carbon storage in agricultural soil and vegetation, including rangelands/pastures, croplands, and vineyards	6,330,070	• *Sonoma County 2010 Crop Report* (Sonoma County Agricultural Commissioner 1991) • *Sonoma County Estimates of 2010 Carbon Stocks by Landcover Class and Carbon Pool* (Climate Action through Conservation Project 2016) • *Baseline Greenhouse Gas Emissions for Forest, Range and Agricultural Lands in California* (California Energy Commission 2004) • *Carbon Sequestration in California Agriculture, 1980–2000* (Kroodsma and Field 2006) • Sonoma County Vegetation Mapping Project
Non-agricultural rural land carbon stock	Carbon storage in vegetation and soil in natural rural lands, such as oak woodlands, riparian woodlands, grasslands, and shrublands	59,712,866	• *Sonoma County Estimates of 2010 Carbon Stocks by Landcover Class and Carbon Pool* (Climate Action through Conservation Project 2016) • U.S. Forest Service Forest inventory and analysis plots for the County. • U.S. Forest Service and U.S. Department of the Interior LANDFIRE program. • Soil Survey Geographic (SSURGO) database for the county. • Environmental Systems Research Institute ArcGIS extension, "Soil Data Viewer" • Sonoma County Vegetation Mapping Project
Urban land carbon stock	Carbon storage in urban forested lands (e.g., urban parks, open spaces, street trees)	1,294,186	• *Sonoma County Estimates of 2010 Carbon Stocks by Landcover Class and Carbon Pool* (Climate Action through Conservation Project 2016) • U.S. Forest Service Forest inventory and analysis plots for the county. • LANDFIRE program. • SSURGO database for the county. • Environmental Systems Research Institute ArcGIS extension, "Soil Data Viewer" • Sonoma County Vegetation Mapping Project

Table 2-5 shows estimated carbon storage in various "reservoirs" (i.e., soil and vegetation). It does not present carbon sequestration or emissions. As noted above, carbon sequestration is the process of increasing the carbon content of a reservoir and represents a "flux" of emissions or a rate of change (e.g., 10 tons of CO_2 sequestered per year).

CA2020 does not include an estimate of annual changes to total carbon stocks in Sonoma County caused by human activities. Details on how the carbon storage values presented in Table 2-5 were estimated can be found in Appendix B. Because carbon cycling in existing soil and vegetation is part of global atmospheric carbon cycling, as opposed to human activities that release geologic carbon through combustion of fossil fuels, the *U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions* (ICLEI – Local Governments for Sustainability 2012) recommends that emissions sinks be disclosed but not combined with other emissions created by human activity in an emissions inventory. Nonetheless, these carbon storage estimates will ultimately become part of a framework to increase biologic sequestration of carbon through protection and management of open and working lands and sustainable agricultural practices that will increase carbon sequestration.

Although this inventory does not estimate changes in carbon storage, CA2020 does include several advanced climate initiatives that will help increase carbon sequestration. Please refer to Chapter 3, *Reducing Community Emissions*, for a discussion of GHG reduction measures that are focused on increasing carbon stock within soils and vegetation.

2.4.3 Emissions from Consumption of Goods and Services

The CAP 2010 inventory is an activity-based inventory that calculates emissions from human activities within Sonoma County. It does not account for global carbon emissions that result from local consumption of goods and services that are produced outside Sonoma County. It does include emissions associated with the production of goods that are grown or made in Sonoma County, including those consumed outside the county.

An alternative approach to quantifying GHG emissions is a so-called "consumption-based" inventory, which includes global lifecycle emissions associated with products (including food) and services used in a particular geographic location or population. These inventories include emissions from fuels and materials used in buildings, transportation, and the production of goods and services outside the local area, including food. A consumption-based approach also looks at total product lifecycle and supply chain emissions, including those associated with harvesting or mining raw materials, manufacturing and processing, and transportation to market. It also includes product use, disposal, and degradation. Most importantly for the purposes of this CAP, consumption-based inventories focus on indirect emissions over which local communities have little direct control, whereas activity-based inventories, like the one included in this CAP, focus on those emissions that a local jurisdiction can more directly influence.

A recent study (Jones & Kammen, UC Berkeley, 2015) presented the first consumption-based inventory of San Francisco Bay Area neighborhoods, cities and counties. According to the study, consumption-based emissions in 2013 were 44.3 metric tons of CO_2e per household in the Bay

Area, compared to 50 metric tons for the average U.S. household. Consumption-based emissions in Sonoma County communities were found to be generally lower than the Bay Area average, ranging from 37.4 to 44.7 metric tons per household. The consumption-based approach used in the UC Berkeley study accounts for much greater emissions from food, goods and services than the activity-based approach used in this CAP. For example, under the consumption-based approach, food generates 19% of all GHG emissions, roughly 3 times more emissions than household energy use. Likewise, goods and services contribute 18% of total emissions. These findings underscore the importance of reducing consumption-based emissions to achieve long-term GHG reduction goals.

Many of the GHG reduction measures included in this CAP will also reduce consumption-based emissions. For example, moving toward 100% renewable electricity (including both utility-scale and distributed generation), combined with electrification of vehicles and heating, will dramatically reduce consumption-based emissions in the transportation and building energy sectors. Likewise, land use and transportation measures in this CAP that focus on higher density infill development near transit will also reduce household carbon footprints. In addition, the *Advanced Climate Initiatives* in Chapter 3 include strategies to reduce emissions related to the consumption of food, goods and services as well as land use and sustainable agriculture strategies that focus on retaining and increasing carbon sequestration in soils and vegetation.

Acknowledging that the activity-based approach alone is incomplete is an important step in understanding the underlying causes of global warming and defining opportunities to reduce our contributions.

2.4.4 Emissions from Air Travel

Emissions resulting from air travel are not included in the inventory because of the challenges in determining the origin and/or destination of flights and because Sonoma County communities do not have control over aircraft sources. Regulation of emissions from aircraft occurs at the federal level. Consequently, emissions from air travel are considered out of scope for this inventory.

Although emissions directly produced by aircraft are not included in the inventory, airport-related emissions (such as energy use in airport buildings) in the county are captured in the inventory and forecasts. Emissions from airport building energy and aircraft ground-support equipment are captured in the building energy and off-road transportation and equipment sectors, respectively.